TEMPORAL AND SPATIAL CHARACTERISTICS OF AIR POLLUTANTS IN AIRPORT ENVIRONMENT

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Ph.D. dissertation

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Theses

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1. INTRODUCTION AND SCIENTIFIC AIMS

The most important environmental issues due to the significant growth in aviation are noise disturbance and air pollutant emission. Aircrafts affect air quality of airport and its surrounding through their Landing and Takeoff (LTO) cycle. Beside precise emission inventory, source characteristics with appropriate time and spatial resolution is needed to determine health effects. Airport air quality studies vary in a wide range. The most important aviation related air quality tasks are to determine emission rates in different operation modes and to analyze the impact of aircraft emission in local and regional scale. Case studies on atmospheric chemical and physical processes can be studied due to the fact that the movement of most sources are registered in detail by the Airport operators. The first aim of this study was to analyze the air quality of the largest airport in Hungary (Budapest) based on a widely used dispersion model and measurement campaign results. Second aim was to determine the chemical composition of airport specific aerosol particles. Beside these, objective was to determine the aircraft engine emission and fresh plume dilution properties.

2. STUDY AREA AND MEASUREMENT CAMPAIGNS

In a framework of a complex research project, air quality measurements were performed at Liszt Ferenc International Airport (hereafter Ferihegy Airport). Measurement campaigns were carried out between 2006 and 2008. During this period, short (few days) and long time (annual) measurements of several compounds were studied at various sites inside the Airport. A monitoring station was installed in 2008, the results of which are partly processed also.

3. METHODS

Measurement methods:

Several instruments were operated during the measurement campaigns. Conventional gaseous compounds atmospheric concentrations were analyzed using standard regulatory environmental gas analyzers. Beside these, a Differential Optical Absorption Spectroscopy (DOAS) () system in open path mode was operated, that enables to examine NO_2 concentration in the atmosphere. Mass concentration of PM_{10} fraction (particles with aerodynamic diameter under 10 μm) was measured using combined Beta attenuation monitoring system (Environnement S.A. MP101-CPM), which is suitable for regulatory agencies. Also, two tapered element oscillating microbalances (Model 1405 TEOM Ambient Air Monitor, Thermo Scientific) were used, which are not regulatory standard instruments. The black carbon content of aerosol particles was measured using a Magee Scientific Portable Aethalometer® Model AE42.

A Dionex DX 300 type ion-chromatography was used to determine the concentration of ionic components of $PM_{2.5}$ size fraction (particles with aerodynamic diameter under 2.5 μm). Size fractioned aerosol samples were also collected with a 7-stage May cascade impactor on silicon wafers. These samples were analyzed using Total reflection X-ray fluorescence spectrometry using high flux synchrotron radiation (SR-TXRF) and X-ray absorption near edge structure (XANES) methods to determine the concentration of trace elements.

Simulation methods:

The spatial distribution of elevated air pollutants concentration due to airport activity was determined with the adaption of EDMS (Emissions and Dispersion Modelling System) (CCSI, 2004), being a widely used dispersion model in airport studies.

Methods for data analysis:

Background concentrations were estimated from the dataset of a suburban station of Hungarian Air Quality Network (Gilice tér). The effect of local sources were filtered using FFT (Fast Fourier Transformation) analysis.

A new method based on statistical dataset of open-path measurements was introduced to study NO_2 emission during takeoff and to describe the time evolution of the fresh plume.

4. THESES

1. The effect of Ferihegy Airport operation on local air quality was studied for the period of 2006-2012 on the basis of measured concentration data and spatial distribution of concentration increments calculated with EDMS. It was observed that the most polluted area inside the Ferihegy Airport is the region of Terminal 2 (so called apron) for NO_X, CO and PM_{10} components. Air Quality Health Index was found to be *acceptable* for all examined compounds except for PM_{10}.

2. Based on the dataset of Hungarian Air Quality Network (HAQN) and that of the monitoring station at Terminal 2, I concluded that during the period of year 2012, 80 percent of measured hourly concentration for CO, NO_X and PM_{10} components are lower at the Airport site than at the closest suburban HAQN station (Gilice tér). According to urban station of HAQN (Széna tér), the ratio of those periods when Airport is more polluted is 12.2% for CO, 3.3% for NO_X and 9.7% for PM_{10}. Limiting value exceedance was detected only for NO_X, in total 8 times at Terminal 2. In case of Gilice tér 54 limiting value exceedance was found for NO_X and 25 for PM_{10}. Overall, I concluded that air pollution load at the most contaminated region of Ferihegy Airport is smaller than in downtown Budapest (Bozó et al., 2006).

3. The verification of EDMS was done using two year dataset (2006 and 2012) of modeling results and concentration data of monitoring station. Comparing the sum of background concentration and simulated concentration increments with measured values, it was proven that the time trends of daily averages for CO, NO_X and PM_{10} compounds show acceptable agreement, which were confirmed by statistical indicators (correlation coefficient, RMSE, bias). Bivariate pollution roses were generated from modeling and measurement results for all studied compounds. It was found that the emission factor of inside and outside road traffic is underestimated by 10 percent, whilst the NO_X emission of aircraft during takeoff mode is overestimated by 15 percent. It was proven, that the contribution of Airport sources can be estimated adequately precise using EMDS in air quality studies of Budapest, taking the above introduced corrections into consideration (Groma et al., 2016).

4. A new method was introduced to study the dilution properties of aircraft engines NO_2 emission. Near-field concentration was studied for various engine and aircraft types (Schaefer et al., 2007). Aircraft emission due to ICAO is defined by the engine types which vary in a wide range. However, it was found that in case of similar aircrafts with different engine types the highest measured concentrations close to emission point deviated only 10 percent. However, more than two times higher ground-field NO_2 concentration increment was detected for aircrafts with different airframe operating engines with similar emission rates. It can be stated that direct determination of emission rate is not possible using near-field NO_2 concentration because of rapid plume dilution. Since the method introduced has the possibility to be adopted for other operation modes, moreover, it is relevant for various air pollutant components as well, it was proven that the DOAS instrument in open-path mode is suitable for emission monitoring to identify extreme emissions.

5. The chemical mass balance of $PM_{2.5}$ for inorganic components was calculated based on the measurement results of a two week long measurement campaign in 2008 summer. It was found that BC is 14.8%, trace element 4.6% and examined ionic compounds (Cl^-, NO_3^-, SO_4^{2-}, NH_4^+) are 17.8% of total $PM_{2.5}$ mass, thus 37.2 percent in all. As a result of a measurement campaign performed at the nearest HAQN station to the Airport in 2015, it was found that inorganic mass content of $PM_{2.5}$ is composed of 4% EC, 6.9% trace element and 29.3% ionic compounds. Maenhaut et al. (2005) published that inorganic mass of $PM_{2.5}$ is 57 percent in downtown Budapest.

6. It was shown that May impactor aerosol sample collection combined with SR-TXRF analysis has the opportunity to achieve detection limits for 20-minute sampling time and 400 l air volume ranging from ng m^{-3} for the light elements (Al, Si) to pg m^{-3} for the medium *Z* elements like Rb and Sr in the ambient aerosol matrix (Groma et al., 2008). Thus, it can be stated that this method is suitable for the quantification of trace elements in very small sample quantity, and enables chemical analysis of

particles emitted from sources with short characteristic times, like touch down (landing). Size fractioned aerosol samples were collected at the runway and Terminal 2. Comparing the elemental composition of these samples, the highest difference was found for copper. Cu concentration in the 2–4 μm size fraction was six times, whilst in 1–2 μm size fraction more than twelve times higher at the runway site. As other ground supporting vehicles traffic at the runway is negligible, it can be supposed that these particles are related to aircraft frame and brake pad erosion. This is confirmed by the results of copper chemical state analysis, which was determined using XANES spectroscopy in combination of TXRF. It was found that whilst the chemical state of copper is Cu(II) in the soil collected on site, the form in coarse mode (2–4 μm) aerosol sample was different, Cu(I) (Osán et al., 2010).

PUBLICATION LIST in connection with the theses

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